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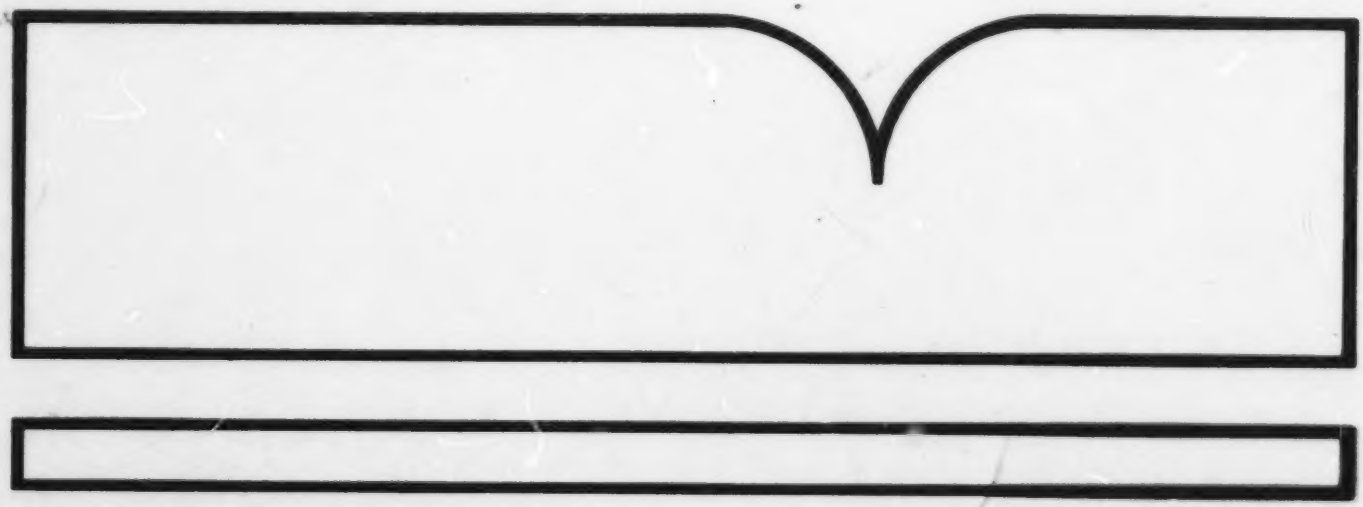
Magnetic Drum Separator Performance Scalping Shredded Trommel Overflow at Nominal Design Conditions. Test No. 4.03 Recovery 1, New Orleans

National Center for Resource Recovery, Inc.
Washington, DC

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Jun 81



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16. ABSTRACT

This report describes the first test (Test No. 4.03) of the "shredded trommel overs" magnetic drum separator at the New Orleans, Louisiana, resource recovery facility (Recovery 1). "Shredded trommel overs" refers to waste which reports to the oversize discharge from the trommel and is subsequently shredded. For this test, the trommel processed raw municipal solid waste at the design feed rate, 62.5 tph.

Three replicate test runs were conducted. For each test run, the two output streams of the magnetic drum separator, i.e., magnetic product and scalped shredded trommel overs, were collected. Both were analyzed to determine bulk density and magnetics content. The magnetics in both were analyzed to determine air-dry moisture loss, composition, particle-size distribution, and contamination by attached non-magnetics. Additionally, samples of feed to the separator were analyzed for total moisture content.

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June 1981

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MAGNETIC DRUM SEPARATOR PERFORMANCE SCALPING SHREDDED TROMMEL OVERFLOW AT NOMINAL DESIGN CONDITIONS

Test No. 4.03, Recovery 1, New Orleans

by

National Center for Resource Recovery, Inc.
Washington, D. C. 20036

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Contract No. 68-01-4423

Project Officer

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FOREWORD

The Environmental Protection Agency was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research, a most vital communications link between the researcher and the user community.

This report documents a performance test at design conditions of the shredded material magnetic drum separator at the New Orleans Resource Recovery Project (Recovery 1). The removal of magnetic material from shredded waste is of benefit in several ways: the volume of waste being landfilled is reduced, a marketable material is recovered, and the value of the non-magnetics as a fuel is enhanced. This report is intended to provide useful data to those designing or operating materials and energy recovery facilities.

Francis T. Mayo
Director
Municipal Environmental Research
Laboratory

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ABSTRACT

This report describes the first test (Test No. 4.03) of the "shredded trommel overs" magnetic drum separator at the New Orleans, Louisiana, resource recovery facility (Recovery 1). "Shredded trommel overs" refers to waste which reports to the oversize discharge from the trommel and is subsequently shredded. For this test, the trommel processed raw municipal solid waste at the design feed rate, 62.5 tph.

Three replicate test runs were conducted. For each test run, the two output streams of the magnetic drum separator, i.e., magnetic product and scalped shredded trommel overs, were collected. Both were analyzed to determine bulk density and magnetics content. The magnetics in both were analyzed to determine air-dry moisture loss, composition, particle-size distribution, and contamination by attached nonmagnetics. Additionally, samples of feed to the separator were analyzed for total moisture content.

This report details test results and describes the magnetic drum separator, its associated equipment, and procedures for testing and sample analyses.

This report was submitted in partial fulfillment of Contract No. 68-01-4423 by the National Center for Resource Recovery, Inc., under the sponsorship of the U. S. Environmental Protection Agency. Testing was carried out in March 1979; data analysis and reporting were completed in February 1980.

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SECTION 1

INTRODUCTION

The recovery of magnetic metals from municipal waste has been practiced in the United States for decades [1]. Resource recovery installations have increased in number and sophistication, and more effective and efficient magnetic separation devices have been developed.

A magnetic separation device should recover the greatest possible amount of available ferromagnetic metal while entraining a minimum of contamination. The snagging of textile, paper, and plastic articles is a common difficulty. No less common is the problem of contamination that has been inserted by the consumer prior to discard of a steel can or other magnetic item. Such contamination can only detract from the market value of the recovered metal. It may be advisable to avoid recovery of such heavily contaminated items if possible. Therefore, the design of the magnetic separation device is not simply a matter of maximizing magnetic field strength.

This report describes a test of a rotary drum electromagnet that is used to recover magnetic items from shredded municipal waste at the Recovery 1 site in New Orleans, Louisiana. The efficiency of the device and the contamination level of magnetics in its input and output streams are discussed. Various design features are examined.

Another report in this series, entitled, "Magnetic Drum Separator Performance Scalping Trommel Underflow at Nominal Design Conditions," [2] describes a rotary drum electromagnet used in a somewhat different application, also at Recovery 1. Comparison with this report will no doubt be instructive.

SECTION 2

SUMMARY OF TEST RESULTS

At Recovery 1, raw municipal solid waste (MSW) is first processed by a large rotating cylindrical screen, or trommel, the surface of which is perforated by circular holes 4.75" in diameter. Material not passing through the openings in the trommel is termed the overflow, or overs. This material is shredded to a nominal 90% -4" product in the Heil shredder. It then passes under the Stearns rotary drum electromagnet, also called the trommel overs magnet. The purpose of this magnet is to remove the magnetic fraction from the shredded trommel overs. The removed portion is referred to as the "product," and the remaining portion as the "tailings." After separation, the product is subjected to a clean-up step which blows off loose organics and separates the light ferrous from the heavy ferrous. The term "as-received" is used to describe the magnetic material with its entrapped contaminant, while "clean" describes the metal after the contaminant has been removed in the laboratory by washing, scraping, etc.

During this test, which consisted of a number of approximately 10-second runs, a total of 206.1 kg (454 lb)** of MSW passed under the magnet. The as-received ferrous component accounted for about 7% of the total weight.

Ferrous objects were classified into one of two subcomponents: light gauge (can stock and container-related items), or heavy (non-can items such as hardware and auto parts). The as-sampled ferrous in the feedstock was approximately evenly divided between the light gauge and heavy subcomponents (see Table 1).

Non-ferrous material attached to the ferrous fraction after passing under the magnet is considered contaminant. It includes, for example, entrapped or attached organics, the ceramic portion

---

*Ferrous fraction is the term commonly used to describe material recoverable by the magnet, even though not all ferrous materials are magnetic.

**A metric conversion table is provided at the end of the text.

TABLE 1. COMPOSITION OF TEST MATERIAL (AS-RECEIVED)

	Test Run 1		Test Run 2		Test Run 3		Total	
	Grams	%	Grams	%	Grams	%	Grams	%
Ferrous in Product								
Light gauge	574		296		1,117		1,987	
Heavy gauge	78		626		95		799	
Total	652	1	922	2	1,212	1	2,786	1.4
Ferrous in Tailings								
Light gauge	1,930		994		1,448		4,372	
Heavy gauge	3,145		1,106		2,204		6,455	
Total	5,075	7	2,100	4	3,652	5	10,827	5.3
Ferrous in Feedstock								
Light gauge	2,504		1,290		2,565		6,359	
Heavy gauge	3,223		1,732		2,299		7,254	
Other Material in Feedstock	68,143	92	45,305	94	79,002	94	192,450	93.4
Total Feedstock	73,870	100	48,327	100	83,866	100	206,063	100

of a spark plug, and the non-metal portion of an oil or juice can. Nonferrous material that is joined to a container during its manufacture, such as solder and tin plate on steel cans or the aluminum tops of bimetal cans, is not considered contaminant.

The efficiency of the magnet is expressed as a percent. It is the weight of as-received ferrous product divided by the weight of as-received magnetics in the feed. The design efficiency of the magnet is 95% [3]. Although this test does not provide a large enough sample to exactly determine the magnet's efficiency, the average for Runs 2 and 3 was 27%, which is substantially below 95%. Only Runs 2 and 3 are averaged. During the first run, due to the electric interlocks, the magnet current and field strength had not reached maximum, so the separation obtained in this run is not considered representative (see Table 2).

The sample data can be used to project daily volumes, the unit of measures typically used on site. During the three runs,

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TABLE 2. EFFICIENCY OF TROMMEL OVERS MAGNET, AS-RECEIVED WEIGHT BASIS

Sub-Component	Magnet Efficiency, %			
	Run 1	Run 2	Run 3	Runs 2 & 3
Light Gauge in Product / Light Gauge in Feed	23	23	44	37
Heavy Gauge in Product / Heavy Gauge in Feed	2	36	4	18
Total Magnetic in Product / Total Magnetic in Feed	11	31	25	27

206 kg of trommel overs passed the magnet in 34.85 seconds. This converts to just about 23-1/2 tph. The nominal trommel rate is 62.5 tph; for each 650 ton-day of MSW processed, 10.4 hours are required. Projecting from the data, the magnetics in the trommel overs would comprise 16.0 tons of ferrous available for recovery for each 650 tons of MSW. With the measured 27% efficiency, 4.3 tons would be recovered and 11.7 tons per day would be lost.

Projecting from the data on a clean-metal basis, the magnetics in the trommel overs would comprise 13.5 tons of ferrous available for recovery for each 650 tons of MSW. With the measured efficiency, 2.7 tons per day would be recovered and 10.8 tons per day would be lost. These figures are based on the totals for Runs 1 and 2 only; data based on clean metal was not available for Run 3. If the magnet were 100% efficient, the contamination level in the ferrous product would be 12-1/2%,* which would not be a significant increase over that which the product from both magnets exhibits at the present time.**

*This is based on Runs 1 and 2 where 1,094 g of contaminant (as-received) was attached to the 7,664 g of clean metal, for a total of 8,758 g. On a clean-metal basis, it is slightly over 14% (1,094 ÷ 7,664).

**In actual practice, loose contamination cleanup and the heavy/light classification are not done perfectly. Not all of the loose contaminants are blown off. Also, some light ferrous is lost to the heavy rejects and some heavy ferrous reports to the marketed product. Finally, the trommel overflow magnet is generally on and the system is run at higher throughput than

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The principal reason for the low recoveries was the placement of the magnet. The air gap between the magnet and the belt is 48% greater than the design air gap, for two reasons. First, the bulk density of the shredded trommel overs is less than expected, resulting in an increased volume. Second, when not testing, the plant is operating at throughputs significantly above the design throughput. The design throughput is 62.5 tph, yet there are days when the plant averages over 100 tph. The magnet's position is fixed and set to avoid jams during high throughput operation. A movable magnet is being installed which can be set in advance for higher or lower burden depths.

Recovery may be calculated on an "as-received" basis using the weight of the magnetics, moisture, and attached contamination; at an intermediate point called "air dried;" or on a clean-metal basis. For example, the magnet efficiencies in Table 2 are based on the weight of the magnets and their attached contaminants, before air drying.

For every 100 kg of magnetic product, on an as-received weight basis, approximately 61.5 kg was light gauge, 33.5 kg was heavy gauge, 4.5 kg was contaminant attached to the light gauge, and 0.5 kg was contaminant attached to the heavy gauge. Loose contaminant accounted for about 0.15 kg. This composition is based on the material found in the product for Runs 2 and 3.

Table 3 displays the composition of the ferrous fraction by weight of the feedstock, product, and tailings.* The high percentage of tin-plated steel, 37% of the feedstock magnetics, reflects the high number of food cans found in the MSW stream. The non-can magnetics were few in number, but they were relatively large and heavy, accounting for 47% of the feedstock magnetics. The concentration of bimetallic cans, 15%, and tin-plated steel cans, 48%, in the product is higher than in the feedstock, 7% and 37%, respectively. The concentration of heavy non-can magnetics in the product, 32%, is lower than in the

measured in the test. The net result is that the marketed product generally has a composition of about 1% loose contaminant, 15% heavy ferrous with about 0.5% entrapped or physically bound contamination, and 74% light ferrous with about 9% entrapped contamination. The total contamination is about 10%. These data were developed from samples taken on site. (Ferrous Metals Recovery at Recovery 1, New Orleans, Runyon, Kelly and Bernheisel, J. F., NCRR, TR-80-1, p. 11.)

*Magnetic sorting categories are shown in Appendix B.

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TABLE 3. COMPOSITION OF THE FERROUS FRACTION IN FEEDSTOCK, PRODUCT, AND TAILINGS FOR RUNS 2 AND 3, AS-RECEIVED WEIGHT BASIS

	Feedstock		Product		Tailings	
	Weight		Weight		Weight	
Category	Grams	%	Grams	%	Grams	%
Light-Gauge (Can)						
Bimetallic	516	7	324	15	192	3
Tin-plated steel food	2,907	37	1,037	48	1,870	33
Composite	294	4	42	2	252	4
Other can	101	1	0	0	101	2
Caps, tops, lids	37	1	11	1	26	1
Heavy-Gauge (Non-Can)						
All-magnetic	3,733	47	688	32	3,045	53
Composite	297	4	33	2	264	5
Total	7,885	100	2,135	100	5,750	100

feedstock, 47%. This indicates that the magnet efficiency was different for the different categories. These results are based on Runs 2 and 3, on an as-received basis.

Table 4 supports this finding. In it are presented the efficiencies of the magnet by component category. The magnet was more efficient on the light gauge fraction than on the heavy. It was more efficient on heavy-gauge all-magnetic particles, 18%, than on heavy-gauge composite particles, 11%.

This point is further amplified by the data in Table 5. That portion of the composite light gauge and composite heavy fraction which was nonmagnetic material was, by definition, contaminant.* After passing under the magnet, the composite lights that reported to the product had only 3% attached

*Contaminant includes material physically joined, as in the case of a can with steel ends and a nonmagnetic body. Note, however, that in all the data developed here, the attached aluminum end of a bimetal can is not considered a contaminant, but in included in the clean-metal magnetic totals.

TABLE 4. MAGNET EFFICIENCY BY FERROUS CATEGORY FOR RUNS 2 AND 3, AS-RECEIVED WEIGHT BASIS

Category	$\frac{\text{Product}}{\text{Feed}}$ (%)
Light Gauge (Can)	
Bimetal	63
Tin-plated steel food	36
Composite	14
Other	0
Caps, tops, lids	30
Heavy Gauge (Non-Can)	
All magnetic	18
Composite	11

TABLE 5. MAGNET EFFICIENCY AND CONTAMINATION - RUN 2 ONLY

	Efficiency		Contamination		
			As-Received Weight Basis		
Category	As-Received Weight Basis %	Clean Weight Basis %	Feedstock %	Product %	Tailings %
Light Gauge (Can)					
Bimetal	26	26	6	3	7
Tin-plated steel	28	28	6	6	6
Composite	11	21	49	3	54
Other can	0	0	4	0	4
Caps, tops, lids	0	0	12	0	12
Heavy Gauge (Non-Can					
All magnetic	37	38	5	1	8
Composite	0	0	55	0	55

contamination while those that reported to the tailings had 54% contamination attached. No composite heavies reported to the product. Those reporting to the tailings had 55% contamination attached. These figures are developed from Run 2 on an as-received weight basis.

An interesting result is the magnet efficiency for tin-plated steel. In the report of a similar test of the trommel underflow MDS [2], there is higher contamination in the tin-plated steel found in the tailings than found in the product. The data in Table 5 do not substantiate this. A possible explanation is the lack of heavily contaminated tin-plated steel in the feedstock.

An alternative method of subdividing the ferrous fraction in the MSW stream is by particle size. Table 6 indicates that 75% of the magnetics (clean-weight basis) were above 2". Further, this group contained 95% (913g/962g) of the contaminant found in the ferrous fraction. The particles greater than 4" were contaminated the most; 31% of their air-dried weight was contaminant. In all, contaminant accounted for 11% of the ferrous fraction.

TABLE 6. PARTICLE SIZE DISTRIBUTION AND CONTAMINATION OF FEEDSTOCK, RUNS 1 AND 2

Particle Size Range	Number of Particles	Weight (Air-Dried)		Weight (Clean)		Contamination*
		(g)	(%)	(g)	(%)	%
+4"	10	2,674	31	2,041	27	24
-4" +2"	60	3,967	46	3,688	48	7
-2" +1"	35	1,301	16	1,272	17	2
-1" +1/2"	41	592	7	575	8	3
-1/2" +1/4"	31	76	<1	73	<1	5
-1/4"	6	15	<1	15	<1	0
All Sizes	183	8,625	100	7,664	100	11

*Contamination is calculated by subtracting the clean weight from the air-dried weight and dividing by the air-dried weight.

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SECTION 3

EQUIPMENT DESCRIPTION

RECEIVING AND SHREDDING BUILDINGS

At Recovery 1, the magnetic drum separators are preceded by several pieces of equipment. A plan view of the trommel, the trommel overs shredder, and associated conveyors is shown in Figure 1. Detailed descriptions of these devices appear in previous work [2,3,4]. In normal operation, a front-end loader places refuse from the receiving area into Pit No. 1. The refuse is transferred by conveyors #150 and #152 to the trommel. That portion which does not pass through the 4-3/4" diameter holes of the trommel is carried to the Heil shredder on conveyor #155. Shredded waste falls on conveyor #157, and is transferred to conveyor #168. This is the feed conveyor for the magnetic drum separator (MDS) #171 tested.

Refuse which passes through the trommel holes falls on conveyor #154 and is transferred to conveyor #169. This is the feed conveyor for the trommel unders magnetic drum separator, previously tested [2].

MAGNETICS RECOVERY

Both magnetic drum separators are positioned atop a trifurcated chute. Gates in the chute control the flow of magnetically scalped waste, directing it either to landfill or to an air classifier. Magnetic product from both separators falls on conveyor #177, which carries it to the ferrous concentrator #176. The concentrator has three output streams:

(1) loose, light nonmagnetics;

(2) heavy ferrous metal objects (auto parts, large hardware, etc.); and

(3) light ferrous objects, primarily food and beverage cans.

A flow diagram of the aforementioned process is shown in Figure 2. Detailed description of MDS #171 and its associated equipment follows.

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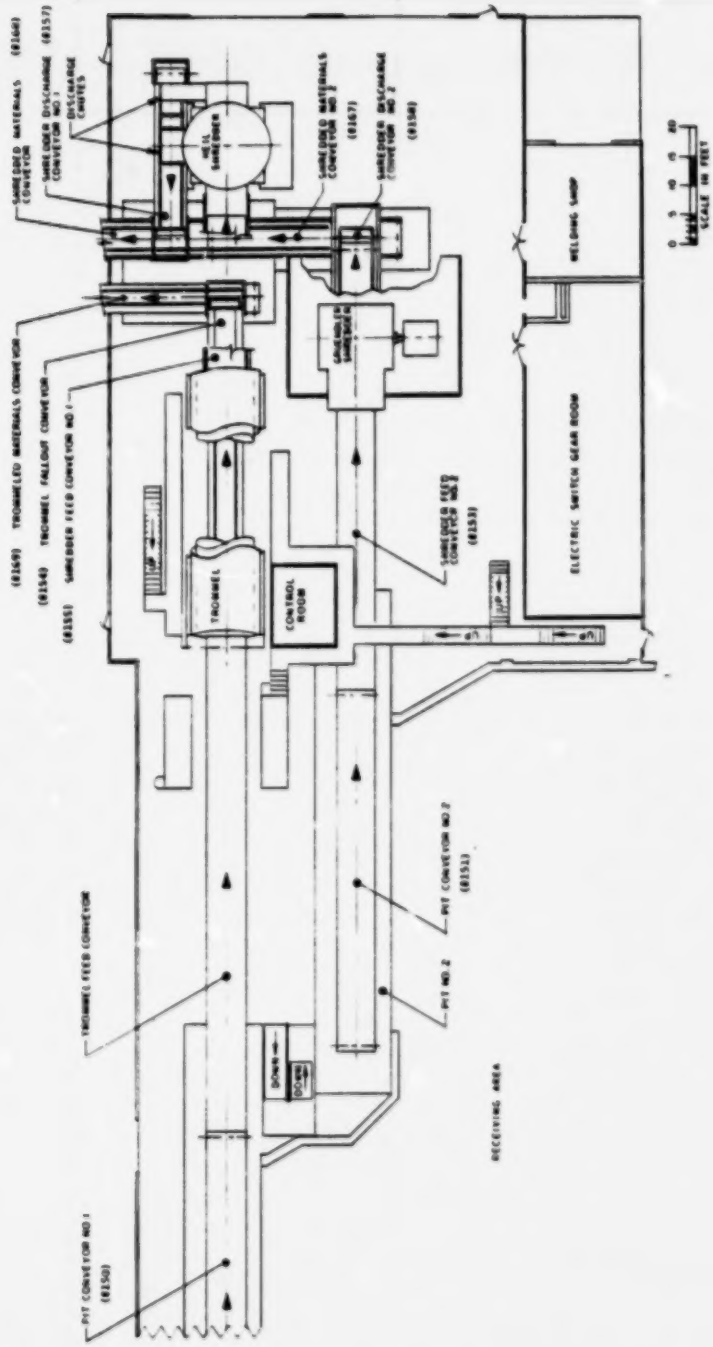

Figure 1. Receiving and shredding buildings equipment arrangement.

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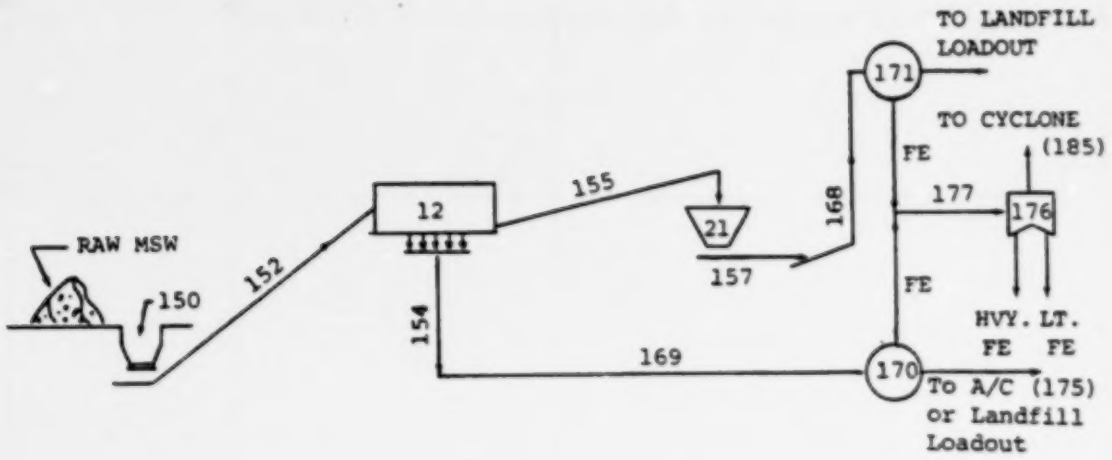

EQUIP. NO.	DESCRIPTION
12	TROMMEL
21	HEIL SHREDDER
150	PIT NO. 1 CONVEYOR
152	TROMMEL INFEED CONVEYOR
154	TROMMEL UNDERS DISCHARGE CONVEYOR
155	TROMMEL OVERS DISCHARGE/ HEIL SHREDDER INFEED CONVEYOR
157	HEIL SHREDDER DISCHARGE CONVEYOR
168	SHREDDED TROMMEL OVERS MDS FEED CONVEYOR
169	TROMMEL UNDERS MDS FEED CONVEYOR
170	TROMMEL UNDERS MDS
171	SHREDDED TROMMEL OVERS MDS
175	TROMMEL UNDERS AIR CLASSIFIER
176	FERROUS CONCENTRATOR
177	FERROUS CONCENTRATOR FEED CONVEYOR

Figure 2. Schematic of Recovery 1 processing through magnetics recovery.

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MDS #171

Stearns rotary drum electromagnet, LD Model 104 LT, Serial No. A-19839 (see Figure 3 for layout of magnet and conveyors).

Drum length: 72" (nominal)

Drum diameter: 48" (nominal)

Drum speed: 25 rpm

Drum drive: 10 hp

Rectifier voltage: 242 V

Rectifier current: 18.5 A hot (test condition)
32.4 A cold

Eight paddles or sweeps, originally 4" in height but cut back to 2" prior to the test, are mounted on the drum surface. Drum is of manganese steel; paddles are stainless steel. Shredded trommel overs are underfed to the counterrotating drum.

Feed Conveyor #168

The feed conveyor is a troughed, inclined, rubber-clad belt conveyor having troughed 35° idlers along most of its length but passing over a cylindrical stainless steel head pulley.

Belt width: 60"

Angle of inclination: 18.5°

Belt speed: 450 feet per minute

Head pulley diameter: 30"

Diameter with belt: 31"

The vertical angle between centers of magnet and head pulley is 22.4°. The air gap between drum face and belt face is 21.4".

Conveyor #168 is offset approximately 2" to one side of the centerline of MDS #171.

Product Conveyor #177

The product conveyor is a troughed, horizontal, rubber-clad belt conveyor. It has troughed 20° idlers along most of its length and passes over cylindrical head and tail pulleys.

Belt width: 36"

Belt speed: 216 feet per minute

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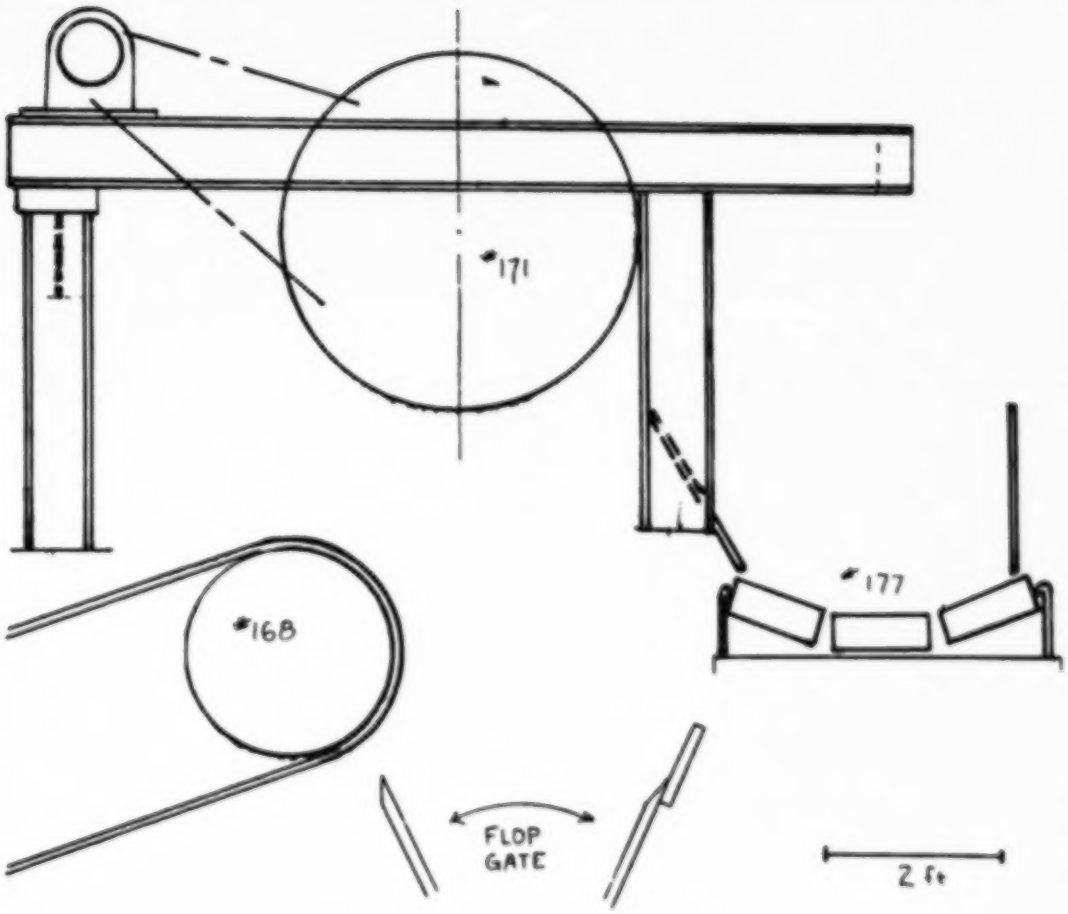

Figure 3. MDS #171, feed conveyor #168, and magnetics product conveyor #177

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SECTION 4

TEST DESCRIPTION

The operating characteristics of equipment under test seriously hampered sampling. In order to measure burden depth prior to a test run, it was necessary to "freeze" the feed conveyor while fully loaded. However, the length of this conveyor (#168) is such that it can only hold slightly more than 10 seconds' worth of test material. Consequently, three test runs of 10 seconds each were planned, separated by three-minute processing periods so that material flow upstream of the MDS could regain steady state.

An outline of the test procedure follows. Staff members were located at four positions: shredder control (SHR), landfill loadout control (LDO), conveyor #168, and conveyor #177. Figure 2 provides a key for most equipment numbers (note: #182 is the reversible loadout conveyor, which loads either a landfill trailer or the sample-collecting dump truck).

TEST PROCEDURE

(1) SHR - Allow conveyor #150 to empty. Run all downstream equipment until clear.

(2) SHR - Supervise discharge of approximately 12 tons of refuse from transfer trailer. Obtain trailer weights before and after unloading.

LDO - Position dump truck under west end of #182.

177 - Disable zero-speed interlock on conveyor #177.

(3) SHR - Push test material into Pit #150. Compute conveyor #150 speed, inform operator.

LDO - Read magnet #171 rectifier amps and volts.

(4) SHR - Process material for 4 - 5 min.

LDO - All ferrous recovery equipment on; #182 loading landfill trailer (east).

177 - Announce when shredded overs flow appears steady.

(5) SHR - Stop trommel and #155.

LDO - Five seconds later, stop #168.

(6) LDO - Stop #177, #171.

168 - At five points along #168, measure burden width and maximum depth.

(7) LDO - #182 loading dump truck (west).

177 - Clean magnet and vicinity of loose metal.

(8) LDO - Start #171. Run #168 for 10 seconds.

177 - Time actual run of #168. Notify LDO when all material is discharged from #171.

(9) LDO - Stop #171.

177 - Retrieve samples from #177.

(10) LDO - Unload dump truck onto tarp. Cover material.

168 - Collect shredded overs sample from 7.5 ft of #168.

(11) LDO - Announce when ready to resume #182 loading landfill trailer (east).

177 - Announce when ready to resume.

(12) SHR - Resume processing for 3 min.

LDO - All ferrous recovery equipment on.

177 - Announce when shredded overs flow appears steady.

(13) Second run: repeat (5) - (12). Third run: repeat (5) - (10).

(14) 177 - Reconnect zero-speed interlock on #177.

(15) LDO, 177 - Announce when finished.

(16) SHR - Resume production.

LDO - Read magnet #171 rectifier amps and volts.

An unanticipated feature of the electrical system interlock control caused a problem which affected results of this test. In the test procedure, Step (6) called for #171 drum drive and coil to be turned off prior to each test run so that stray material could be cleared from the vicinity of the magnet. During Run 1, it was found that #171 would not restart without first starting #168. Several seconds are required for magnet current and field strength to reach a maximum. Consequently, the magnet had to power up at the start of Run 1 sampling [Step (8)]; the resulting measure of magnet efficiency for that run is inordinately low. This is discussed further in Section 6.

The aforementioned problem was avoided for Runs 2 and 3 by leaving magnet coil and drum on at all times. Test runs were completed satisfactorily.

SECTION 5

DESCRIPTION OF SAMPLE ANALYSES

MOISTURE SAMPLE

Sample Division

It was necessary to reduce the size of each moisture sample to one-eighth of the initial volume by coning and quartering [5] three times. These representative subsamples were then air dried, oven dried, and screened.

Drying

Air drying was accomplished by spreading the shredded refuse on the floor of a ventilated room to a depth of less than one inch (2.5 cm). Air drying continued for two full days. Further drying was done in a laboratory oven with internal volume of 9 ft^3 (255 dm^3). Oven temperature was set to 103°C. Oven drying required two additional days, until the rate of weight loss in any four-hour period was less than 0.1% of the sample weight after air drying.

Screening

Each of the oven-dried subsamples was screened separately on the Gilson Testing Screen, using 4-in. (102 mm), 2-in. (51 mm), 1-in. (25 mm), 1/2-in. (13 mm), and 1/4-in. (6.4 mm) screens. Subsamples were divided into two or three batches as necessary to prevent screen overloading. Duration of screening was 30 min., after which time the rate of weight change in the -1/4-in. fraction was less than 0.1% of the total sample weight per minute.

MDS PRODUCT

The following procedure was carried out separately on material from each of the three test runs.

Initial Weight, Bulk Density

MDS product material was weighed on a triple-beam balance (capacity: 2,610 g, readibility: 0.1 g) immediately after collection. To find its volume, each sample was placed in a

watertight plastic bag; after excess air was removed with a laboratory aspirator, the bag was immersed in a container approximately half full of water. Volume was derived from the change in water level. Bulk density was computed as follows:

$$B = \frac{W}{V_2 - V_1} \quad (1)$$

where B = bulk density, lb/ft^3 (kg/m^3)
W = net weight of sample, lb (kg)
V_2 = volume of sample and water
V_1 = volume of water

Sorting

MDS product was hand sorted into the following categories:

Paper	Ferrous
Yard waste	Aluminum
Plastic	Other non-ferrous
Other heavy organics	Glass
	Stone & ceramic
	-1/4" fines

Ferrous material was further hand sorted into the following categories:

Bimetal cans	Other cans
Tin-plated steel cans	Caps, tops, lids
Composite cans	Non-can, all magnetic
	Non-can composite

These categories are defined in Appendix B. Less than one hour was required to complete the sorting for one run. Sorted material was placed into 11-gallon plastic bags, one mil thick, which were sealed and weighed on the triple-beam balance.

Air Drying

Bags of sorted material were opened and allowed to air dry in a warm ventilated room for one week. Material was spread so that it was not more than one particle deep.

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Moisture Loss

After air drying, the sorted material was replaced into 11-gallon bags and weighed. Moisture loss was computed as follows:

$$M = \frac{W_1 - W_2}{W_1} \times 100 \qquad (2)$$

where M = moisture loss, as-received basis, %
W_1 = weight before air drying
W_2 = weight after air drying

Screening

Nonmagnetic Material--

The loose nonmagnetic material isolated in previous sorting was hand sized, i.e., paper, plastics, yard waste, etc., was manually compared with a caliper set to the appropriate gap (4", 2", down to 1/4"). If an item could pass through a square opening of a given size, it was checked at each lower size until the "screen" on which it would rest was determined. This method was used instead of screening because of the small number of particles involved.

Magnetic Material--

Each component of the magnetic material was screened separately on the Gilson Testing Screen. The -1/4" fraction was weighed after 1, 5, and 10 minutes of screening. For all magnetic components, ten minutes were sufficient to meet the aforementioned criterion for completion of screening.

After each screening, the material in each size fraction was placed in 4-gallon plastic bags and weighed.

Decontamination

Magnetic material may be contaminated by food waste and other nonmagnetics placed in a can at the time of disposal. In addition, contaminants may be pinched and held by magnetics during compaction in a packer truck or transfer trailer. The weight of such contaminants must be deducted from the total weight of a given size of component (e.g., -4" +2" bimetal cans) to obtain the weight of clean metal. "Clean metal" as used in this report includes lacquers, paints and coatings, tin plating, solder, aluminum tops of bimetal cans, and adhesive rubber or plastic lid gaskets.

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First, a bag containing a particular size of a component was weighed on the triple-beam balance or dial balance (capacity: 310 g, readibility: 0.01 g), as appropriate. Magnetics were then decontaminated, as described in the following paragraph.

Decontamination has been done frequently at Recovery 1 as a quality-control check. Consequently, a list of the most common cans, their cleaned metal weights, and the variability of those weights (expressed as a coefficient of variation) has been developed. These known clean weights were used in lieu of manual cleaning whenever the coefficient of variation was less than 5.0%. For the rest of the sample, all attached nonmagnetic material that could be removed manually by such means as scraping, drying, and wiping was removed. The remaining clean magnetic material was reweighed.

MDS TAILINGS

Initial Weight, Bulk Density

This material had been collected in a dump truck after discharge below the drum magnet. Material from each test run was covered with a waterproof plastic sheet until analysis took place. It was then shoveled into a 2 ft^3 (57 dm^3) fiber drum lined with a 30-gallon plastic bag 1.5 mil thick. As the drum was filled, this liner bag was sealed, removed, and later weighed. From 23 to 41 such bags were needed to contain the tailings from a test run. A composite bulk density for each test run was computed.

Residual Magnetics

Each bag of MDS tailings was hand picked for magnetics using an Alnico magnet. Residual magnetic material was placed in an 11-gallon plastic bag and weighed. When grossly contaminated items (e.g., a board with two nails in it) were found, the entire item was considered a residual magnetic in this first step. Several large textile items containing small amounts of magnetic material were found. These were analyzed as a separate component; later it was decided to treat them as nonmagnetics.

Residuals were subsequently analyzed in a similar manner as for magnetic material in MDS product. Bulk density was found using the volume occupied in a 2 ft^3 fiber drum; then, sorting, air drying, screening, and decontamination were performed.

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SECTION 6

TEST RESULTS

This section expands on the information provided in Section 2, Summary of Test Results. The general format allows for the presentation of data on the composition of the feedstock, product, and tailings material streams. Composition by category and particle size, material characteristics, and flow rates are presented. Finally, the efficiency of the magnet is examined by category of magnetics and by particle size. Results based on "air-dried" material data are introduced to show, by comparison with Table 5, Column 1 (p. 7), the effects of moisture on the results.

During Run 1, the magnet coil current and field strength had not reached maximum, so Run 1 data have been omitted from some calculations. Data on the composition of the tailings are not complete for Run 3, so they also have been omitted from some calculations. Raw data describing all samples of product and tailings may be found in Appendix A.

COMPOSITION OF MATERIAL STREAMS

Feedstock

Table 7 gives a breakdown, by category, of the ferrous metal objects (magnetics) in the feedstock. This was found by summing the appropriate weights of magnetic material in product and tailings.

Ferrous metal objects in the feed are primarily in one of two categories. Tin-plated steel cans are sometimes too large to pass through the trommel holes; smaller cans also report to trommel overs, as trommel screening efficiency is less than 100%. The large amount of tin-plated steel cans in raw refuse is the ultimate reason for their high percentage among magnetics in the MDS feed. Non-can all-magnetic items included (in this test) steel tubing from a large children's toy, and parts of kitchen appliances. While relatively few in number, these are weighty items; moreover, they are usually too large to report to trommel unders. Hence they outweigh other ferrous metal components in the feedstock. Other data concerning feedstock are summarized in Table 8.

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TABLE 7. COMPOSITION OF MAGNETICS IN FEEDSTOCK, BY CATEGORY

Category	Wt % Air-Dry Basis with Attached Contaminant*	Wt % Clean Basis**	Wt % Contamination Air=Dry Basis**
Bimetal	5.51	4.51	5.70
Tin-plated steel	36.62	36.66	3.73
Composite can	3.17	1.91	51.08
Other can	0.74	1.27	2.38
Caps, tops, lids	0.53	0.58	14.47
Non-can all mag	46.65	54.15	2.29
Non-can composite	6.76	0.94	88.77
TOTAL	100.0	100.0	

*Runs 1, 2, and 3.
**Runs 1 and 2 only.

TABLE 8. MDS FEEDSTOCK CHARACTERISTICS

Bulk density (as-received)*	2.54 lb/ft^3
Moisture content (as-received basis)†	21.7%
Percent ferrous, with attached contaminant (as-received)**	6.61%
Moisture content of ferrous fraction (as-received)**	1.4%
Percent contamination of magnetics (air-dry basis)††	11.2%

*Composite of moisture samples (168 samples).
†Composite of oven-dried moisture subsamples.
**Runs 1, 2, and 3.
††Runs 1 and 2 only.

Particle size distribution (PSD) of the oven-dried moisture subsamples (composited) is given in Table 9. Total weight screened was 7.37 lb (3.34 kg). This includes any ferrous material that was collected as part of the moisture sample. A slight (3.5%) increase in weight occurred during the 30-minute screening as oven-dried samples regained moisture from the atmosphere. Relative humidity during screening was approximately 60%.

TABLE 9. COMPOSITION OF FEEDSTOCK BY PARTICLE SIZE

Size Range	Wt % on Screen	Cumulative Wt % Passing Screen
+4"	11.5	88.5
-4" +2"	16.9	71.6
-2" +1"	27.3	44.2
-1" +1/2"	20.7	23.5
-1/2" +1/4"	7.3	16.2
-1/4"	16.2	--

The mass flow rates of feedstock were computed for each test run. The product and tailings weights (as-received) were summed and divided by run time. The average mass flow rate was 23.47 tons per hour (see Table 10).

The preceding data give an indication of trommel performance. The percentage of infeed mass reporting to the trommel overs is (23.5/62.5) x 100 = 37.7%. This agrees with earlier testing [2,4].

MDS Product

For each of the three test runs, the nonmagnetics reporting to the product make up less than 0.3% of the as-received total product. Only a few small bits of paper were entrained with the captured magnetics. This loose contamination has been neglected in the discussion which follows.

Table 11 gives a breakdown, by components, of the magnetics in the product. It was formed by summing data from Runs 2 and 3

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TABLE 10. MASS FLOW RATES OF FEEDSTOCK

Run	Mass Flow Rate (tph)
1	24.94
2	16.54
3	28.95
Composite	23.47

TABLE 11. COMPOSITION OF MAGNETICS IN PRODUCT, BY CATEGORY*

Category	Wt %, Air-Dry Basis with Attached Contaminant	Wt %, Clean Basis	Wt % Contamination Air-Dry Basis
Bimetal	14.67	14.99	1.60
Tin-plated steel	48.67	47.39	6.25
Composite can	1.96	1.91	5.93
Other can	0.0	0.0	--
Caps, tops, lids	0.54	0.56	0.27
Non-can all mag	32.66	33.69	0.65
Non-can composite	1.51	1.46	6.87
TOTAL	100.01	100.00	

*Runs 2 and 3 only.

only; Run 1 was neglected because the magnet was not operating at full power for all of the test interval.

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As with the feed, product material is predominantly tin-plated steel cans and non-can all-magnetic items. By comparison with the initial hand sorting categories shown in Table 7 (p. 22), the following observations may be made:

(1) Product is richer in bimetal cans and tin-plated steel cans than is the ferrous component of feedstock.

(2) Most composite can material in the feedstock did not report to the product. That which did report to the product is remarkably clean compared to the feed material. This is discussed further under Magnet Efficiency in this section.

(3) Non-can material is less highly concentrated in the product than in the feedstock. Here again, product material is cleaner.

Table 12 summarizes other MDS product data.

TABLE 12. MDS PRODUCT CHARACTERISTICS

Bulk density (as-received)*	11.38 lb/ft^3
Moisture content (as-received basis)**	1.50%
Percent ferrous, with attached contaminant (as-received)**	100%
Percent contamination of magnetics (air-dry basis)**	37%

*Composite of the three product samples.
**Runs 2 and 3 only.

Table 13, particle size distribution, was prepared using data from Runs 2 and 3. From this table, 90% of the magnetics in the product would be retained on a 2" screen. However, screening after magnetic separation would not select the less-contaminated ferrous product; as a cleanup process, it would be inappropriate.

Average mass flow rates of product for each test run are given in Table 14. Recall that Run 1 was begun with magnet power off, while the magnet was at full power throughout Runs 2 and 3.

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TABLE 13. COMPOSITION OF MAGNETICS IN PRODUCT, BY PARTICLE SIZE*

Size Range	Wt % on Screen (Air-Dry Basis)	Cumulative Wt % Passing Screen	% Contamination (Air-Dry Basis)
+4"	17.4	82.6	0.76
-4" +2"	71.3	11.3	4.60
-2" +1"	10.3	1.0	2.81
-1" +1/2"	0.9	0.1	0.81
-1/2" +1/4"	0.1	0.0	3.00
-1/4"	0.0	--	--

*Runs 2 and 3 only.

TABLE 14. MASS FLOW RATES OF PRODUCT

Run	Product Mass Flow (As Received) (tph)	Run Time (sec)	Recovered Material (As Received) (lb)
1	0.223	11.75	1.45
2	0.317	11.6	2.04
3	0.421	11.5	2.69

MDS Tailings

In analyzing samples of tailings, magnetics were sorted into components defined in Appendix B. One additional component was defined to account for large (>4") textile items containing a very small amount of magnetic metal (Table 15). Because of their large size and low ferrous metal content, it was subsequently decided to exclude the component from the magnetics in the tailings.

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TABLE 15. LARGE TEXTILES IN TAILINGS

Run	All Tailings (lb)	Large Textiles (lb)	Clean Metal in Large Textiles (lb)	Clean Metal in Large Textiles (%)
1	161.4	0.99	0.09	9.1
2	104.5	0.99	0.006	0.6
3	182.2	7.98	unknown	unknown
1 & 2 total	265.9	1.98	0.096	4.9
1, 2, 3 total	448.1	9.96	unknown	unknown

Also excluded were those contaminants which adhered to magnetics when culled from tailings but which came loose during subsequent sorting into categories. These comprised no more than 0.15% of the magnetics in the tailings for any run.

Table 16 gives a breakdown by categories of the magnetics in the tailings for Run 2. Where available, data from Run 1 are inserted in parentheses.

Tin-plated steel cans and non-can all-magnetic items are again in the majority. Comparing with Table 7 (feedstock) and Table 11 (product), the relative concentrations of most categories are similar in product, feed, and tailings. Composite can concentration is lower in product than in tailings; moreover, the tailings composite cans show much greater contamination than those in the product. A composite can with its cardboard body attached to the end(s) is much more likely to be held down by other material and report to the tailings. Free ends of composite cans report more easily to ferrous product and are cleaner as well. This is one way in which the magnet functions as a differential separator.

Table 17 permits comparison of the relative concentrations of components in feedstock, product, and tailings for Run 2. For Run 2, the balance of components in product (and tailings) approximates that in the feed. Also, the magnetics in the tailings are usually more heavily contaminated. The limited data available from Runs 1 and 3 (Appendix A) support these conclusions.

Other data concerning tailings are summarized in Table 18.

TABLE 16. COMPOSITION OF MAGNETICS IN TAILINGS BY CATEGORY

Category	Wt %, Air Dry Basis with Attached Contaminant		Wt % Clean Basis	Wt % Contamination Air-Dry Basis	
	Run 2	Run 3		Run 2	Run 3
Bimetal	4.48	(2.72)	4.61	6.85	(3.19)
Tin-plated steel	30.67	(33.74)	32.26	4.89	*
Composite can	6.56	(2.88)	3.46	52.28	(46.97)
Other can	4.80	(0.00)	5.18	2.38	*
Caps, tops, lids	0.83	(0.24)	0.81	11.77	(6.80)
Non-can all mag	51.68	(53.99)	53.16	7.00	*
Non-can composite	0.98	(6.42)	0.51	52.92	(96.34)
TOTAL	100.00		99.99		

*No samples.

TABLE 17. RUN 2 MAGNETICS IN FEED, PRODUCT, AND TAILINGS, BY CATEGORY

Category	Wt %, Clean Basis			Wt % Contamination Air-Dry Basis		
	Feed	Product	Tailings	Feed	Product	Tailings
Bimetal	4.23	3.44	4.61	5.18	3.31	6.85
Tin-plated steel	30.15	25.76	32.26	5.02	5.36	4.89
Composite can	2.96	1.91	3.46	46.51	1.49	52.28
Other can	3.50	0.00	5.18	2.38	*	2.38
Caps, tops, lids	0.55	0.00	0.81	11.77	*	11.77
Non-can all mag	58.27	68.89	53.16	4.69	0.72	7.00
Non-can composite	0.35	0.00	0.51	52.92	*	52.92

*No samples.

TABLE 18. MDS TAILINGS CHARACTERISTICS

Bulk density (as-received)*	2.11 lb/ft^3
Percent magnetics, with attached contaminant (as-received)*	4.42%
Moisture content of magnetics (as-received basis)**	1.28%
Percent contamination of magnetics (air-dry basis)**	24.8%

*Runs 2 and 3.
**Run 2 only.

Particle size distribution for the magnetics in the tailings (Run 2 only) appears in Table 19.

TABLE 19. COMPOSITION OF MAGNETICS IN TAILINGS, BY PARTICLE SIZE*

Size Range	Wt % on Screen (Air-Dry Basis)	Cumulative Wt % Passing Screen	% Contamination (Air-Dry Basis)
+4"	21.4	78.6	15.72
-4" +2"	56.3	22.3	10.23
-2" +1"	9.9	12.4	4.09
-1" +1/2"	11.8	0.6	0.57
-1/2" +1/4"	0.5	0.03	0.46
-1/4"	0.03	--	0.00

*Run 2 only.

From comparison with Table 13 (product particle size), the following may be inferred. First, for sizes above one inch, the less-contaminated material is more likely to report to the product. Second, if all magnetics in the tailings could be made to report to the product, a further cleanup process would be

needed for magnetics larger than two inches in order to keep overall contamination below 10%.

Table 20 gives average mass flow rates of tailings for each test run.

TABLE 20. MASS FLOW RATES OF TAILINGS

Run	Tailings Mass Flow (as Received) (tph)	Run Time (sec)	Sample Weight (as Received) (lb)
1	24.73	11.75	161.4
2	16.22	11.6	104.5
3	28.52	11.5	182.2
Composite	23.14	34.85	448.1

MAGNET PERFORMANCE

Magnet Efficiency

Magnet efficiency, or recovery, is defined as the fraction or percentage of ferromagnetic metal in the feedstock which reports to the MDS product. It may be computed using clean metal weights, or on a more convenient basis if necessary (see Table 21).

TABLE 21. MAGNET EFFICIENCY

Run	Magnet Efficiency, Clean Basis (%)	Magnet Efficiency, with Contamination Attached, Air Dry (%)
1	12.6	11.5
2	32.4	30.7
3	Unknown	24.6

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Note that Run 1 was begun with magnet power off, while the magnet was at full power for all of Runs 2 and 3.

This test did not provide enough data to conclusively state the magnet efficiency or a statistically derived range in which magnet efficiency should lie. However, an efficiency of 30% (clean basis) conforms to the data shown and to operating experience at Recovery 1. This is much less than the design efficiency, 95% [3].

Table 22 gives magnet efficiency as a function of contamination for Run 2 only. Note that particle shape and size have not been controlled. With further testing, enough data may become available to control for these variables. Using the data at hand and neglecting components weighing less than 100g, an inverse relationship is apparent.

Table 23 gives magnet efficiency as a function of the size of particles in the feed for Run 2 only. A direct relationship is apparent. Contamination, which is less than 10% in all cases, probably has little effect.

The recovery, or magnet efficiency, for each component is given in Table 24. Note that this table applies to Run 2 only, due to incomplete analysis of Run 3 samples and change in magnet strength during Run 1. While the table shows magnet performance during a brief interval (11.6 sec), it is useful in comparison with the performance of MDS #170 (see Ref. 2). It also illustrates the function of the magnet as a differential separator. For example, 3.36% of the product material is bimetal cans (clean metal); another 0.11% of the product is contaminant attached to those bimetal cans. The recovery of bimetal cans (clean metal) was 26.39%, but only 14.30% of the contamination attached to all feedstock bimetal cans reported with recovered product. The greater the difference between recovery of clean metal and recovery of attached contaminant, the more effective is the magnet as a differential separator.

Design Versus Actual Performance

Both the placement and the performance of this MDS differ considerably from design. Table 25 provides data comparing as-designed to as-tested placement and performance.

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TABLE 22. MAGNET EFFICIENCY VS FEED CONTAMINATION LEVEL, RUN 2

Contamination, Air-Dry Basis (%)	Magnet Efficiency, Clean Basis (%)	Category	No. of Particles	Weight (Air Dried) (g)
2.38	-0-	Other cans	1	99.49
4.69	38.37	Non-can all mag	19	1,695.83
5.02	27.72	Tin-plated steel	14	880.58
5.18	26.39	Bimetal	4	123.80
11.77	-0-	Caps, tops, lids	6	17.25
46.51	20.92	Composite cans	7	153.35
52.92	-0-	Non-can composite	3	20.39

TABLE 23. MAGNET EFFICIENCY VS FEED PARTICLE SIZE, RUN 2

Size Range	Magnet Efficiency, Clean Basis (%)	% Contamination Air-Dry Basis	No. of Particles	Weight (Air Dried) (g)
+4"	49.3	8.87	5	810.27
-4" +2"	32.4	7.98	24	1,682.83
-2" +1"	7.4	3.99	9	237.54
-1" +1/2"	1.5	0.61	13	249.16
-1/2" +1/4"	-0-	0.48	4	10.85
-1/4"	-0-	0.0	2	1.03

TABLE 24. COMPOSITION OF STREAMS AND PERCENT RECOVERY BY MDS (#171)
RUN 2 OF MARCH 15, 1979

		Stream			Mass Split of Feed to Product/% Recovery
		MDS Product	MDS Tailings	MDS Feed	
Stream mass flow rate, as-received		0.317 tph	16.22 tph	16.54 tph	1.92%
% Loose contaminants, as-received		0.0%	95.57%	93.74%	0.0%
% Magnetics, as-received		100.0%	4.43%	6.26%	30.62%
Magnetics Composition, As-Received Weight Basis					
Bimetal cans	CM*	3.36%	4.12%	3.89%	26.39%
	A-DAC**	0.11	0.30	0.25	14.30
Tin-plated steel cans	CM	25.15	28.79	27.68	27.72
	A-DAC	1.43	1.48	1.46	29.72
Composite cans	CM	1.86	3.09	2.71	20.92
	A-DAC	0.03	3.38	2.36	0.36
Other cans	CM	0.0	4.63	3.21	0.0
	A-DAC	0.0	0.11	0.08	0.0
Caps, tops, lids	CM	0.0	0.72	0.50	0.0
	A-DAC	0.0	0.10	0.07	0.0
All can-related magnetics	CM	30.37	41.35	37.99	24.39
	A-DAC	1.57	5.37	4.22	11.35
All non-can magnetics	CM	67.26	47.91	53.81	38.14
	A-DAC	0.49	4.09	2.99	4.96
All magnetics	CM	97.63	89.26	91.80	32.45
	A-DAC	2.06	9.46	7.21	8.70
Air-dry moisture loss		0.31	1.28	0.99	9.97

*CM = clean metal
**A-DAC = air-dried attached contamination

Trommel infeed data: 62.34 tph
Shredded trommel overs moisture: 21.7%

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TABLE 25. MDS (#171) AS-DESIGNED VS AS-TESTED OPERATING PARAMETERS AND PERFORMANCE

	As-Designed	As-Tested
Feed mass flow rate	75 tph (max)*	23.47 tph
Nominal particle size of feed	<5"	94% <5"
Bulk density of feed	3.5 lb/ft^3	2.54 lb/ft^3
Magnetics content of feed	7 to 10% (wet wt)	6.61% (wet wt)
Inclination (above horizontal) of feed conveyor (#168)	17.9°	18.5°
Feed conveyor belt speed	300 to 350 fpm	450 fpm
Air gap (between belt and drum surfaces)	14.5"	21.4"
Angle (between a line joining shafts of #168 head pulley and MDS, and the vertical)	30°	22.4°
Offset (between feed conveyor and MDS centerlines)	0	2"
Maximum magnetic strength (at feed conveyor belt surface, est)	460 gauss at 21.1A	140 gauss at 18.5A
% recovery of magnetics	95% (wet wt)	~28% (wet wt) ~30% (clean metal)
Percent loose contaminants in product	5%	0.0%

*Designed for Line 2 operation - no trommel before shredding.

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REFERENCES

1. Pavoni, J. L., et al, Handbook of Solid Waste Disposal, Van Nostrand Reinhold Company, New York, 1975, 535 pp.

2. National Center for Resource Recovery, Inc., "Magnetic Drum Separator Performance Scalping Trommel Underflow at Nominal Design Conditions," report for the U. S. Environmental Protection Agency, Office of Solid Waste Management Programs, Contract No. 68-01-4423, Cincinnati, Ohio, 1980, 62 pp.

3. National Center for Resource Recovery, Inc., New Orleans Resource Recovery Facility Implementation Study - Equipment, Economics, Environment, National Center for Resource Recovery, Inc., Washington, D. C. 1977, 427 pp.

4. Bagalman, P. M., Bernheisel, J. F., Parker, W. S., "Trommel Performance at Nominal Design Conditions," report for the U. S. Environmental Protection Agency, Office of Solid Waste Management Programs, Contract No. 68-01-4423, Cincinnati, Ohio, 1978, 129 pp.

5. American Society for Testing and Materials, "Method for Reducing Field Samples of Aggregate to Testing Size," No. C702, Philadelphia, PA, 4 pp.

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APPENDIX A

TEST DATA

TABLE A-1. TEST NO. 4.03 DATA SHEET - March 15, 1979

1. Feedstock
   (a) Source: Florida Avenue transfer station
   (b) Transfer trailer number and capacity: TT 18, 75 yd^3
   (c) Date @ time received: March 15, 1979, @ 8:09 AM
   (d) Weight of refuse unloaded: 21,300 lbs
2. Length of Pit No. 1 conveyor (#150) filled: 51.5 ft
3. Specified trommel infeed rate: 62.5 tph
4. Pit No. 1 conveyor (#150) speed required: 5.04 fpm
5. Pit No. 1 conveyor speed set: 5.06 fpm
6. Shredded trommel overs conveyor (#168) speed: 450 fpm
7. MDS (#171) rotational speed: 25 rpm
8. Air gap between MDS (#171) and feed conveyor (#168) belt surfaces: 21.4 in.

	Run 1	Run 2	Run 3	Composite or Average
9. MDS (#171) coil supply voltage:				
Volts:	244	244	244	244
Amps:	18.2	18.5	18.8	18.5
10. MDS (#171) magnetic field strength at conveyor (#169) belt surface (gauss)	0-138*	140	142	140
11. Feed time to trommel (secs)	355	160	100	615 (total)
12. Average trommel infeed mass flow rate (tph)				62.34
13. MDS feed conveyor (#168) burden				
average depth (in.)	7.2	7.6	8.8	7.87
width (in.)	34.7	34.7	34.7	34.7

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TABLE A-1 (continued)

	Run 1	Run 2	Run 3	Composite or Average
14. Feed time to MDS (#171) (sec)	11.75	11.6	11.5	34.85
15. MDS product collected				
(a) Weight (lb)	1.45	2.04	2.69	6.18
(b) Mass flow rate (tph)	0.223	0.317	0.421	**
(c) Bulk density (lb/ft^3)	14.04	29.88	7.48	11.38
(d) Magnetics content (as received) (lb)	1.440	2.033	2.672	6.145
(e) Magnetics content (clean) (lb)	1.355	1.985	2.478	5.818
16. Scalped shredded overs collected (tailings)				
(a) Weight (lb)	161.4	104.5	182.2	448.1
(b) Mass flow rate (tph)	24.73	16.22	28.52	23.14
(c) Bulk density (lb/ft^3)	3.51	2.00	2.18	**
(d) Magnetics content (as received) (lb)	11.190	4.629	8.051	23.870
(e) Magnetics content (clean) (lb)	9.429	4.132	Unknown	
17. Shredded overs feed to MDS (#171)				
(a) Weight (lb)	162.85	106.54	184.89	454.28
(b) Mass flow rate (tph)	24.95	16.54	28.94	23.46
(c) Bulk density on feed conveyor (lb/ft^3)	3.60	2.00	2.67	2.79
(d) Moisture content (wet-weight basis) (%)	21.7	18.7	25.0	21.7
(e) Magnetics content (as received) (lb)	12.630	6.662	10.723	30.015
(f) Magnetics content (clean) (lb)	10.784	6.117	Unknown	

*Magnet was not at full power for entire run.
**Composite not given; low magnet efficiency in Run 1 introduced bias.

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TABLE A-2. RUN 1 MDS PRODUCT, COMPOSITION/PSD

TEST NO: 4.03
DATE: March 15, 1979
RUN NO: 1
SAMPLE: MDS Product

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE +4	-4 +2	-2 +1	-1 +1/2	-1/2 +1/4	-1/4	TOTAL
BIMETALLIC CANS WT (GMS) 48.20		1 12.99 41.94 48.20					1 12.99 41.94 48.20
TIN-PLATED STEEL FOOD CANS WT (GMS) 519.36		10 5.00 483.37 508.80	1 0.13 7.35 7.36		1 0 0.74 0.74		12 4.92 491.46 516.90
COMPOSITE CANS WT (GMS) 0.0							
OTHER CANS WT (GMS) 0.0							
CAPS, TOPS, LIDS WT (GMS) 6.89			1 0 6.84 6.84				1 0 6.84 6.84
NON-CAN, ALL METALLIC WT (GMS) 44.37			1 3.59 18.57 19.26	1 41.06 3.47 5.89	2 0.84 19.06 19.22		4 7.37 41.10 44.37
NON-CAN, COMPOSITE WT (GMS) 34.06				1 2.03 33.37 34.06			1 2.03 33.37 34.06
TOTAL WT (GMS) 652.88		11 5.69 525.31 557.00	3 2.10 32.76 33.46	2 7.78 36.84 39.95	3 0.81 19.80 19.96		19 5.48 614.7 650.37

NUMBER OF PARTICLES ⇦ ▭ ⇨ % ATTACHED CONTAMINANTS

AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS ⇦ ◪ ⇨ AIR-DRY WEIGHT (GMS), CLEAN METAL

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TABLE A-3. RUN 2 MDS PRODUCT, COMPOSITION/PSD

TEST NO: 4.03
DATE: March 15, 1979
RUN NO: 2
SAMPLE: MDS Product

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE													
	+4		-4 +2		-2 +1		-1 +1/2		-1/2 +1/4		-1/4		TOTAL	
BIMETALLIC CANS WT (GMS) 31.89					1	3.31							1	3.31
					32.04	30.98							32.04	30.98
TIN-PLATED STEEL FOOD CANS WT (GMS) 246.87			3	5.40			1	3.21					4	5.16
			241.18	228.16			3.84	3.72					245.02	231.86
COMPOSITE CANS WT (GMS) 17.62			1	1.49									1	1.49
			17.42	17.16									17.42	17.16
OTHER CANS WT (GMS) ____														
CAPS, TOPS, LIDS WT (GMS) ____														
NON-CAN, ALL METALLIC WT (GMS) 625.69	1	0.76	2	0.66									3	0.72
	366.64	363.85	257.98	256.29									624.62	620.14
NON-CAN, COMPOSITE WT (GMS) ____														
TOTAL WT (GMS) 922.07	1	0.76	6	2.90	1	3.31	1	3.21					9	2.06
	366.64	363.85	516.58	501.61	32.04	30.98	3.84	3.72					919.10	900.16

NUMBER OF PARTICLES ⇐ | | ⇒ % ATTACHED CONTAMINANTS
AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS ⇐ \ ⇒ AIR-DRY WEIGHT (GMS), CLEAN METAL

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TABLE A-4. RUN 3 MDS PRODUCT, COMPOSITION/PSD

TEST NO: 4.01
DATE: March 15, 1979
RUN NO: 3
SAMPLE: MDS Product

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE																	
	+4		-4 +2		-2 +1		-1 +1/2		-1/2 +1/4		-1/4		TOTAL	
BIMETALLIC CANS WT (GMS) 291.96			6	1.40									6	1.40
			276.28	272.41									276.28	272.41
TIN-PLATED STEEL FOOD CANS WT (GMS) 789.76			10	7.09	5	0.20							15	6.53
			707.07	656.95	70.88	70.23							777.95	727.18
COMPOSITE CANS WT (GMS) 21.91					3	9.19							3	9.19
					23.72	21.54							23.72	21.54
OTHER CANS WT (GMS) ____														
CAPS, TOPS, LIDS WT (GMS) 11.44					1	0.27	4	0.27					5	0.27
					2.74	2.73	8.57	8.55					11.31	11.28
NON-CAN, ALL METALLIC WT (GMS) 62.03					1	0	1	0	1	3.00			3	0.05
					55.01	55.01	5.73	5.73	1.00	0.97			61.74	61.71
NON-CAN, COMPOSITE WT (GMS) 32.76					1	6.87							1	6.87
					31.74	29.56							31.74	29.56
TOTAL WT (GMS) 1211.86			16	5.49	11	2.72	5	0.16	1	3.00			33	4.99
			983.35	929.36	184.09	179.07	14.30	14.28	1.00	0.97			1182.74	1123.68

NUMBER OF PARTICLES ⇦ | | ⇨ % ATTACHED CONTAMINANTS

AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS ⇦ \ ⇨ AIR-DRY WEIGHT (GMS), CLEAN METAL

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TABLE A-5. RUN 1 MDS TAILINGS, COMPOSITION/PSD

TEST NO: 4.01
DATE: March 15, 1979
RUN NO: 1
SAMPLE: MDS Tailings

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE													
	+4		-4 +2		-2 +1		-1 +1/2		-1/2 +1/4		-1/4		TOTAL	
BIMETALLIC CANS WT (GMS) 194.28			4	3.17			1	17.20	3	8.82			8	1.22
			183.79				1.13		1.06				185.98	
			190.21				1.80		1.16				193.17	
TIN-PLATED STEEL FOOD CANS WT (GMS) 1556.16			12	1.76	11	4.09	7	2.78	7	25.50			37	2.59
			1038.24		376.66		58.54		8.44				1481.88	
			1056.93		392.73		60.21		11.13				1521.20	
COMPOSITE CANS WT (GMS) 149.04			2	63.96	4	3.29							6	55.90
			45.36		18.66								64.02	
			125.88		19.29								145.17	
OTHER CANS WT (GMS) ____														
CAPS, TOPS, LIDS WT (GMS) 29.93			1	24.70			4	13.41	1	12.24			6	19.75
			11.84				8.17		2.09				22.10	
			15.72				9.44		2.38				27.54	
NON-CAN, ALL METALLIC WT (GMS) 2536.86	4	0.60	6	1.06	8	0.29	12	0.61	11	0.28	4	0	45	0.58
	1279.72		335.08		615.95		217.71		30.16		14.31		2492.93	
	1287.48		338.67		617.76		219.06		30.24		14.31		2507.52	
NON-CAN, COMPOSITE WT (GMS) 608.76	1	95.98					2	56.04	2	41.12			5	95.03
	23.75						5.24		0.23				29.22	
	575.84						11.93		0.39				588.16	
TOTAL WT (GMS) 5075.03	5	30.05	25	6.55	23	1.80	26	3.85	24	7.75	4	0	107	14.18
	1303.47		1614.31		1011.27		290.79		41.98		14.31		4276.13	
	1863.32		1727.41		1029.78		302.44		45.50		14.31		4982.76	

NUMBER OF PARTICLES
AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS
% ATTACHED CONTAMINANTS
AIR-DRY WEIGHT (GMS), CLEAN METAL

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TABLE A-6. RUN 2 MDS TAILINGS, COMPOSITION/PSD

TEST NO: 4.03
DATE: March 15, 1979
RUN NO: 2
SAMPLE: MDS Tailings

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE																			
	+4			-4 +2			-2 +1			-1 +1/2			-1/2 +1/4			-1/4			TOTAL		
BIMETALLIC CANS WT (GMS) 91.05				1	2.20		1	33.24					1	1.11		1	0		4	6.85	
					49.49			34.15						2.07			0.70			86.41	
				50.60			39.36						2.10			0.70			92.76		
TIN-PLATED STEEL FOOD CANS WT (GMS) 640.06				7	5.07		2	1.00					1	3.35					10	4.89	
					576.58			27.28						0.62						604.48	
				607.36			27.56						0.64						635.56		
COMPOSITE CANS WT (GMS) 142.46				4	57.87		1	0.75		1	0.35								6	52.28	
					51.70			3.92			9.25									64.87	
				122.70			3.95			9.28									135.93		
OTHER CANS WT (GMS) 100.86				1	2.28		1	5.63											2	2.28	
					94.22			2.90												97.12	
				96.42			3.07												99.49		
CAPS, TOPS, LIDS WT (GMS) 17.37							1	19.71		5	7.88								6	11.77	
								4.55			10.67									15.22	
							5.67			11.38									17.25		
NON-CAN, ALL METALLIC WT (GMS) 1084.21	4	15.66		4	1.31		2	1.28		4	0.16		2	0.09		1	0		17	7.00	
		374.16			267.29			124.28			222.04			8.11			0.33			996.23	
	443.63			270.85			125.89			222.39			8.11			0.33			1071.20		
NON-CAN, COMPOSITE WT (GMS) 21.40				1	58.42					2	4.16								3	52.92	
					7.62						1.98									9.60	
				18.32						2.07									20.39		
TOTAL WT (GMS) 2099.41	4	15.66		18	10.23		8	4.10		12	0.56		4	0.48		2	0		48	0.59	
		374.16			1046.90			197.08			243.94			10.80			1.03			1873.91	
	443.63			1166.25			205.50			245.32			10.85			1.03			2072.58		

NUMBER OF PARTICLES ⟵ ⟶ % ATTACHED CONTAMINANTS

AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS ⟵ ⟶ AIR-DRY WEIGHT (GMS), CLEAN METAL

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TABLE A-7. RUN 3 MDS TAILINGS, COMPOSITION/PSD

TEST NO: 4.03
DATE: March 15, 1979
RUN NO: 3
SAMPLE: MDS Tailings

COMPONENT (AS RECEIVED WT.)	SIEVE-SIZE RANGE													
	+4		-4 +2		-2 +1		-1 +1/2		-1/2 +1/4		-1/4		TOTAL	
BIMETALLIC CANS WT (GMS) 29.21			2	3.19									2	3.19
			98.80	95.65									98.80	95.65
TIN-PLATED STEEL FOOD CANS WT (GMS) 1229.76*														
COMPOSITE CANS WT (GMS) 109.78			3	49.14	1	9.93							4	46.27
			98.55	50.12	5.77	5.20							104.32	55.32
OTHER CANS WT (GMS) ____														
CAPS, TOPS, LIDS WT (GMS) 8.83							4	6.80					4	6.80
							8.83	8.23					8.83	8.23
NON-CAN, ALL METALLIC WT (GMS) 1860.76*														
NON-CAN, COMPOSITE WT (GMS) 242.85	2	99.41	1	95.76	2	91.17					1	0	6	96.34
	140.53	0.83	12.27	0.52	79.83	7.05					0.11	2.11	232.74	8.51
TOTAL WT (GMS) 3651.19	2	99.41	6	70.23	3	85.66	4	6.80			1	0	16	62.28
	140.53	0.83	209.62	146.29	85.60	12.25	8.83	8.23			2.11	0.11	444.69	167.71

*Samples not analyzed for size distribution or contamination

NUMBER OF PARTICLES ⇦ ▭ ⇨ % ATTACHED CONTAMINANTS

AIR-DRY WEIGHT (GMS), WITH CONTAMINANTS ⇦ ◺ ⇨ AIR-DRY WEIGHT (GMS), CLEAN METAL

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APPENDIX B

MAGNETICS SORTING CATEGORIES

CAN-RELATED MAGNETICS

Bimetallic Cans

These are containers constructed of principally two metals: magnetic steel for the body and bottom, and aluminum for the top. They commonly appear in MSW as post-consumer beverage containers: beer, soda, juice, etc. Two types of construction predominate:

(1) Three-piece construction, with a steel body and bottom and an aluminum top. These commonly appear in 12-, 8-, and 6-fluid ounce capacities.

(2) Two-piece construction with a single-piece, wrought-steel body and bottom and an aluminum top. These commonly appear in 12-fluid ounce capacity. Both types usually have lacquer/pigment labels. The aluminum top of a two-piece can represents a larger proportion of the total weight than for the three-piece can.

Tin-Plated Steel Food Cans

This category includes a large variety of containers which have different shapes, capacities, wall thicknesses, etc., but have in common that they are tin-plated magnetic steel containers that were used for packaging foods. They are of three- or two-piece construction and commonly appear with a paper label affixed to the can by adhesive or with a lacquer/pigment label. Common examples are cans used to package soups, vegetables, tuna fish, evaporated milk, chili, etc. Also included in this category are the ends of cans cut out by the consumer.

Composite Cans

These are cans constructed with one or two magnetic steel ends and a mainly non-metallic body. The bodies are commonly constructed mainly of paperboard or plastic. Common examples

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are frozen juice, biscuit, and motor oil containers. Some motor oil containers are of two-piece construction with a one-piece plastic body and bottom and a steel top; other motor oil and other containers are of three-piece construction originally manufactured with a non-metallic body and two steel ends.

Other Cans

This category encompasses the remainder of post-consumer containers constructed of magnetic steel. Common examples are aerosol cans, paint and solvent cans, lighter fuel cans, motor oil, brake fluid, and other automotive fluid cans. Some are tin-plated and have lacquer/pigment or paper labels.

Caps, Tops, Lids

This category includes magnetic steel bottle caps, tops removed from composite cans, jar lids, etc., which had once sealed a container and were usually removed by the consumer by prying, unscrewing, etc. They are often painted or lacquered, and may contain waxed paperboard or plastic gasket liners.

NON-CAN MAGNETICS

All-Magnetic Non-Can

This category of magnetics includes miscellaneous items originally manufactured of magnetic metal, e.g., hardware, hangers, wire, strapping, tools, etc. The category contains magnetic items which were galvanized, chrome-plated, painted, lacquered, or otherwise coated in their original manufacture. These items are considered to be all-magnetic. In addition, the category contains those all-magnetic items with foreign materials (contaminants) attached as the result of co-mingling in the refuse.

Composite Non-Can Magnetics

This category includes miscellaneous non-can-related items constructed in part of magnetic metal. Examples are: a leather belt with a magnetic buckle, various auto parts (steel spark plugs with ceramic collars, steel oil filters with paper elements, etc.), plastic or wooden clothes pins with a steel spring, lumber with steel nails embedded, a steel kitchen utensil with a plastic handle, etc.

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